# SPECIFICATION

Electronic Version 1.2.8

Stylesheet Version 1.0

# Solar Blind Detector Using SiC Photodiode and Rugate Filter

## Background of Invention

[0001] The present invention relates generally to solar blind detectors. It finds particular application in conjunction with missile detection and tracking and will be described with particular reference thereto. It will be appreciated, however, that the invention is also amenable to other like applications, e.g., fire detection.

[0002] Vehicles (e.g., aircraft) operating in hostile environments need a wide variety of increasingly sophisticated devices to assure their survival. In order to intercept missiles, for example, launched from either the ground or air, they must be detected as early as possible. Early detection allows evasive action and other counter measures to be taken, which greatly reduces the effectiveness of such missiles. Early warning systems that detect ultraviolet (UV) from a missile's plume typically incorporate solar blind UV filters. Conventional filters provide a sharp attenuation in a short spectrum period to give a black background for the event being viewed and eventually detected. The filters are employed to improve the performance of light detectors having unsuitable operating characteristics.

[0003] Typical, solar blind detectors are Geiger Muller gas filled thyratron tubes. Short wavelength UV photons (e.g., $\lambda \leq 270$ nm) strike a coated cathode which emits electrons. High voltage (e.g., $V \geq 800$ volts) between the cathode and anode of the tube accelerates the electrons, which causes the electrons to impact gas molecules. In this manner, the gas molecules are ionized. Once the gas molecules are ionized, a gas avalanche occurs and the voltage across the tube drops. The voltage drop represents a signal drop that indicates a detection of UV photons.

[0004] There are several drawbacks associated with the solar blind detectors currently used:1)Because the tube is not a solid state device, a high voltage supply is required.

[0005] 2)The process for making the cathode coating sensitive to UV is difficult to control.

[0006] 3)The tube and its power supply are heavier, more expensive and less reliable than a solid state device. Furthermore, the high voltage line poses a safety and potential explosive danger. Therefore, such devices are not compatible with modern low voltage solid state electronics.

[0007] 4)There has been an attempt (and much research done) for the purpose of replacing the solar blind Geiger Muller tube with AlGaN photodiodes. These photodiodes have not as yet been successful for a number of technical reasons, including:a)The amount of Al in the AlGaN starting material needs to be excessive (e.g., $\geq$ 40%). Material quality suffers at such a high level of Al.

[0008] b)AlGaN photodiodes have excessive dark current (e.g., $\geq 1\ \mathrm{nA/cm}^2$).

[0009] c)Because AlGaN photodiodes exhibit a long wavelength responsivity tail when the Al concentration approaches 40%, AlGaN photodiodes are not completely solar blind.

[0010] d)Good AlGaN photodiodes are not yet available because the yield is very low. The low yield is caused by crystal defects that occur during the epitaxial growth of AlGaN layers on sapphire or even SiC substrates.

[0011] e)Electron trapping effects make the recovery times of AlGaN photodiodes relatively long. Therefore, such photodiodes are not compatible with high speed detection systems.

[0012] f)An Si diode having a phosphor coating may be utilized if an appropriate filter is utilized. However, the most used filter is composed of organic films that are not reliable for temperatures $\geq$ ° C and the dark current of an Si diode is considerably higher than that of SiC.

[0013] For the reasons stated above, attempts to utilize Geiger Muller tubes for solar blind applications (e.g., missile detection and tracking) have been very disappointing.

[0014] The present invention provides a new and improved apparatus and method which overcomes the above-referenced problems and others.

## Summary of Invention

[0015]

A detector includes a filter for substantially blocking photons having wavelengths of

greater than about 250 nm. A photodiode has a low dark current less than about 0.4 $pA/cm^2$. A current from the photodiode is proportional to a quantity of photons having wavelengths less than or equal to about 250 nm, which pass through the filter and impinge the photodiode. A processor determines the quantity of photons impinging the photodiode as a function of the current.

[0016] In accordance with one aspect of the invention, the photodiode has a bandgap of greater than or equal to about 2.7 eV.

[0017] In accordance with a more limited aspect of the invention, the photodiode is an SiC photodiode.

[0018] In accordance with another aspect of the invention, the filter provides a rise characterized as from less than about 50% reflectance to more than about 97% reflectance within a range of less than about 3 wavelengths. The filter also provides a cutoff characterized as from greater than about 99% reflectance to less than about 50% reflectance within a range of less than about 25 wavelengths.

[0019] In accordance with a more limited aspect of the invention, the filter is a Rugate filter. A multiple dielectric layer filter composed of alternate layers of silicon nitride ($Si_3N_4$) and silicon dioxide ($SiO_2$) or alternate layers of hafnium oxide ($HfO_2$) and $SiO_2$ could also be used.

[0020] In accordance with another aspect of the invention, the filter includes inorganic material not degraded by temperatures greater than or equal to about 175 °C.

[0021] In accordance with a more limited aspect of the invention, the inorganic material includes $SiO_2$ and $Si_3N_4$ or $SiO_2$ and $HfO_2$.

[0022] In accordance with another aspect of the invention, the photons are included within a missile plume, or fire flame, such as occurs when gasoline burns or explodes.

[0023] In accordance with another aspect of the invention, a signal conditioner transforms the current from the photodiode into a signal transmitted to the processor. The processor determines the quantity of photons impinging the photodiode as a function of the signal.

[0024] In accordance with a more limited aspect of the invention, the current from the